Paying bills*

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Abstract

paying bills

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1. Pitch

Why structure?

- cool counterfactuals
  1. full welfare of pre-paid meters (with revenue equaling counterfactual)
  2. how do interest rate changes affect water demand and delinquency? spillover effects!?
- measure consumption distortions from water loans [shows up with first one..]
- estimate a revealed credit constraint parameter using utility data
  1. show that they are substitutes!

This paper looks at whether utilities in developing countries provide an important source of credit to households by letting them not pay their bill? And how do these benefits compare to the costs of delinquency?

Motivation : (1) around the world, there are restrictions on when utilities can disconnect people (health, low-income, elderly), motivated by providing a sense of insurance; (2) Also, in developing countries, pre-paid metering where utilities essentially put fancy meters that only distribute water when people pay first. these shut off any credit channel but eliminate delinquency

Context : In Manila, water bills make up about 3% of income on average, jumps to 5 to 10% for low-income folks. I have data from a large water provider serving half the city of Manila. On average, people make a payment in three out of four months and are about a month behind in payments. For example, if you don't pay for three months, that's like taking a three-month loan of around 9% of your income.

People might be paying infrequently because they are credit-constrained and consumption smoothing; or it might just be a pain to pay their bills so they just avoid the hassle by paying infrequently (and they have plenty of other opportunities to smooth).

I use disconnection threats to better isolate the role of credit constraints. Workers will occasionally visit delinquent customers and say if you don't pay your bill soon (within 12 days on average), we'll disconnect you. Only 23% of people say that's "enough time" to pay the bill. After the threats, payments spike to double the average bill, delinquency drops to zero, and consumption drops by around 25%. If it were simply a hassle, people would pay their bill and consumption wouldn't change (they could get easy credit from other places and pay the bill); but if they are credit constrained, they have to deviate from consumption smoothing to make the payments. The next step is to use theory to see what this decrease in consumption implies about the short-term interest rate that households face.

2. Introduction

2.1. Question

Are utilities providing an important source of credit to households by letting them not pay their bill?

2.2. Motivation

- Disconnection policies as insurance (in the US)
  - weather, health, low-income
  - mandate that utilities amortize arrears
  - Utilities even tolerate greater non-payment
- At the same time, pre-paid metering is growing like crazy in the developing world (Sources)

2.3. Descriptives

- Avg Income: 22,000 PhP (488 USD) [Bill 3%]
- Avg Savings: 4,300 PhP (96 USD)
- 20% Income: 8,300 PhP (184 USD) [Bill 7.6%]
- 20% Savings: 330 PhP (7 USD)
- Avg Bill: 630 PhP (14 USD)
- Make payments 75% of months
- Avg delinquency: 30 days
- Avg Payment Amount: 830 PhP (18 USD)

But : might just be inconvenient to pay every month (but its really easy to pay bills in this context)

How can I ballpark this against the consumption smoothing literature?

2.4. Approach

Disconnection : Don't pay bill; come and threaten disconnection

- avg days to pay : 12 days (only 23% say that's enough time)
- if you (agree to?) pay, you are reconnected after 2 days

- 30% of connections are threatened with disconnection
- (small percent actually disconnect)
- Pay (+1) 800 PhP (+2) 300 PhP = total 1100 PhP (24 USD) [about two water bills on average]
- Consumption drops by about 20% for two months (there is a pre-trend which can be interpreted as positive demand shocks)

Theory :

- suddenly this source of credit is cut off (loan with uncertain payback date)
- concave utility predicts that households would want to smooth consumption (could get another loan, then fund consumption in that period)
-

3. Data

To measure water consumption and payments, I partnered with a large water provider in Manila who shared administrative data on over 1.5 million water connections. These data include water consumption and payment data as well as disconnection status.

Describe notice of disconnection in more detail here???

used to measure water consumption and payment data comes from monthly administrative data from a large water provider in Metro Manila

The 2015 Family Income and Expenditure Survey provides household income measures, which help to calibrate the structural model.

STICK WITH ONE HOUSEHOLD PER METER IN THIS PAPER! EXPLAIN THIS IN THE DATA SECTION! CONNECT TO FIES DATA AS WELL!!

4. Credit through Unpaid Water Bills

Unpaid water bills may provide a reliable source of low-cost credit to households because (1) the company tolerates high rates of delinquency before disconnecting them from service and (2) the water company is prohibited from charging any interest on outstanding balances.

At the end of each month, the water company sends meter readers who record monthly consumption for each connection and then use a mobile device to print and deliver the bill to the household in person. The household is then expected to pay the bill by the end of the month. Households have many options to pay their bills with 79% using small payment centers (mall kiosks, gas stations, convenient stores, etc.), 17% paying at local water company offices, and 3% paying over phone, online, or via

Table 1. Mean Characteristics

	Mean	SD	Min	25th	75th	Max
Usage (m3)	24.9	17.0	0.0	14.0	32.0	200.0
Bill	692	927	-4,640	265	854	78,409
Unpaid Balance	1,523	4,611	-4,995	0	1,126	79,904
Share of Months with Payment	0.71	0.45	0.00	0.00	1.00	1.00
Payment Size	924	1,147	0	316	1,082	62,879
Days Delinquent	50.2	133.6	0.0	0.0	31.0	720.0
Delinquency Visits per HH	0.42	0.71	0.00	0.00	1.00	6.00
Share of Months Disconnected	0.04	0.19	0.00	0.00	0.00	1.00

Total Households: 34,406 Obs. per Household: 61.7 Total Obs.: 2,123,335

ATM kiosks.[1] Despite easy payment mechanisms, households rarely pay their bills on time. Table 1 provides summary statistics on the usage, billing, and payment patterns of households. On average, households are 50.2 days behind in their payments. Households also make large, infrequent payments. While the average bill is 691.6 PhP per month, payment sizes average 1,529.0 PhP and households make payments in only 71% of months. These payment patterns leave an average total outstanding balance of 1,523.0 PhP per month.

Given average monthly household incomes of 31,910 PhP and savings rates of 4,836 PhP in Manila, unpaid water bills reach 4.8% of income and 31.5% of savings on average each month. For households at the 20th income percentile, unpaid water bills jump to 10% of monthly income. As a benchmark, Cull et al. [2009] survey microfinance institutions throughout the developing world and find median yearly loan sizes expressed as a share of the 20th percentile of household income at 48% for nongovernmental organizations (NGOs), 160% for nonbank financial institutions, and 224% for banks. These descriptives suggest that a yearly loan from an NGO could be reached with around 5 months of unpaid water bills for households at the 20th income percentile.[2] Moreover, microfinance loans charge high yearly interest ranging from 25% for NGOs to 13% for banks. In comparison, unpaid water bills are interest-free, but households face some risk of service disconnection for delinquency.

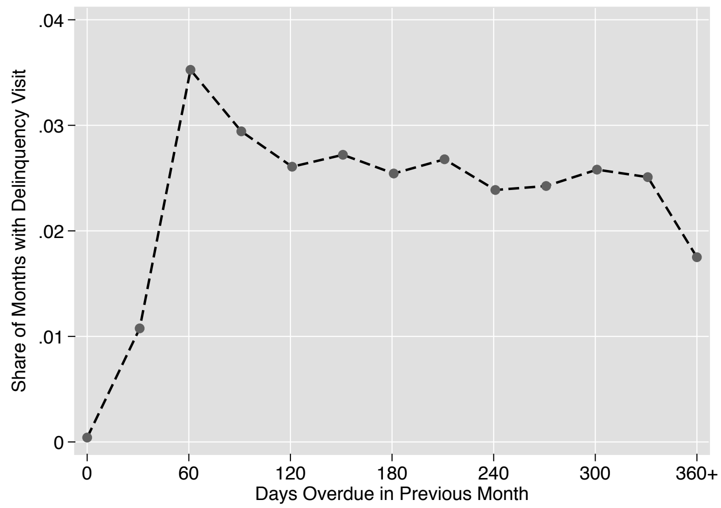
After bills have remained unpaid for at least 60 days, the government regulator permits the water company to visit delinquent households to disconnect their water service.[3] Likely due to time and travel costs, delinquency visits are relatively rare in practice, occurring in only 0.70% of household-month observations. This probability increases to 2.90% for household-months over 60 days overdue. Figure 1 plots the

[1] Figures are tabulated from the connection survey sample.

[2] Deal with income effects on water consumption!

[3] Regulations also require the water company to issue written statements to households, notifying them that their connections will be disconnected in 7 days if their outstanding balances remain unpaid. In practice, only 36% of disconnected households report receiving advanced notice. All percentages are calculated from 924 respondents who report being visited for disconnection in the past year out of 34,406 total respondents in the connection survey.

Figure 1. Share of Households that Receive a Delinquency Visit depending on Days Delinquent in the Previous Month



share of months with delinquency visits according to days overdue. The risk of delinquency visits spikes at 61 days overdue before settling to around 2.5% at higher levels of delinquency. Appendix Table 11 predicts delinquency visits with days overdue, outstanding balance, and household characteristics. This exercise finds that days overdue and unpaid balances are strongly and independently correlated with visits while demographic indicators have weaker associations.

When company staff conduct delinquency visits, households often negotiate for additional time to pay their outstanding balances. 96% of households report agreeing to pay within 30 days and the average grace period is 13 days; however, only 25% of connections report having "enough time" to make their payments. For households who fail to pay, disconnection typically involves workers from the water company placing a metal lock on the water meter stopping the flow. In order to reconnect, households must pay a small, one-time fee of 200 PhP on top of settling any outstanding balances. The water company is then required to restore service within 48 hours of receiving full payment for reconnection, which is confirmed in survey data.[4]

Table 2 provides mean characteristics according to whether and how households respond to delinquency visits over the course of the sample. The first column, "Never Visited," includes households that never receive a delinquency visit. Since delinquency visits are relatively rare, the majority of observations fall into this category. The second and third columns include households that receive at least one delinquency visit. The second column, "Stayers," also requires that households are connected for the final 6 months of the sample while the third column, "Leavers," includes households that are disconnected for at least one of the final 6 months of the sample.

Leavers are predominantly composed of households that permanently disconnect over the sample period, which likely occurs when households move out of their current

[4]Households report being reconnected 2.3 days after payment.

Table 2. Mean Characteristics by Delinquency Visit Status

	Never Visited	Stayers	Leavers
Usage (m3)	24.3	26.2	26.3
Bill	658	761	833
Unpaid Balance	706	2,416	6,520
Share of Months with Payment	0.78	0.60	0.38
Payment Size	829	1,214	1,247
Days Delinquent	18.9	84.9	236.5
Delinquency Visits per HH	0.00	1.32	1.42
Months Disconnected	0.01	0.03	0.31
HH Size	5.2	5.6	5.7
Age of HoH	47.4	44.8	45.8
Low Skilled HoH	0.14	0.17	0.19
Total Households	23,727	8,260	2,419
Total Observations	1,464,945	509,959	148,431

"Never Visited" includes HHs that never receive a delinquency visit.
"Stayers" includes HHs with ≥1 visit and are connected for the last 6 months.
"Leavers" includes HHs with ≥1 visit and are disconnected for ≥1 of the last 6 months.
Bill, Unpaid Balance, and Payment Size are in PhP/month.

residences. These households often leave large outstanding balances that are almost never repaid due to difficulties tracking households across locations. By incentivizing households to pay, frequent delinquency visits provide a strategy for the company to minimize this lost revenue.

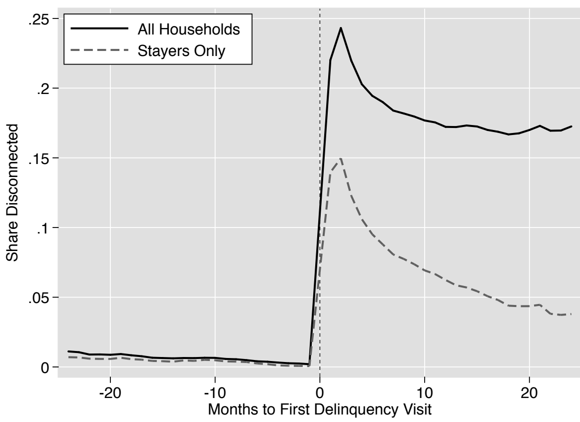
Stayers include households that remain connected at the end of the sample despite receiving at least one delinquency visit over the duration.[5] Compared to households that are never visited, stayers have much higher outstanding balances and days delinquent. Their payments also occur less frequently but have larger average sizes. Stayers spend 3% of the sample period disconnected from service. Until they are able to pay for reconnection, these households likely substitute to alternative water sources including sharing with neighbors, using from deepwells, or purchasing from local water vendors.[6] Stayers also have slightly larger household sizes, younger heads of household, and greater incidence of low-skilled employment than never visited households. These demographic patterns are consistent with lower-income households having greater difficulty paying their bills promptly.

To investigate the timing of household responses to delinquency visits, Figure 2 plots monthly mean outcomes in months relative to the first delinquency visit for each household. Outcomes are plotted separately for all households that experience delin-

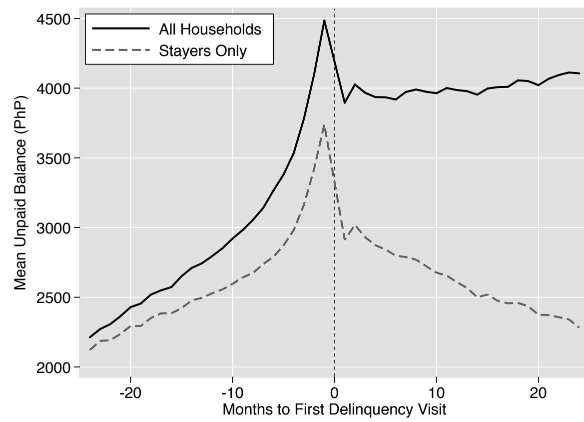
[5]Stayers also excludes 45 households that the company has flagged as "permanently disconnected."

[6]Table 2 indicates that even for households that are never visited, they are disconnected during 1% of months. These disconnections include (1) households that received a delinquency visit before the start of the sample (but later reconnected) and (2) households that notify the water company about their moving plans in advance and therefore, do not need a delinquency visit.

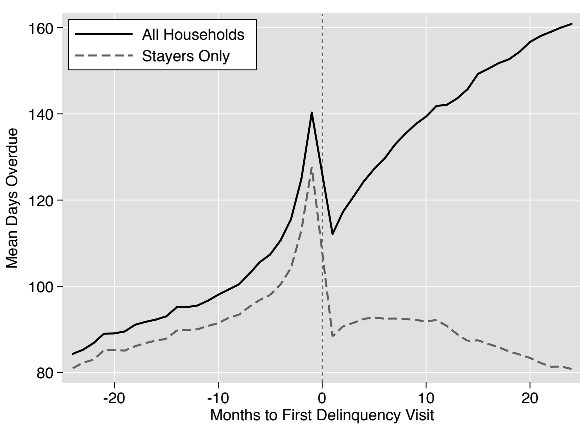
(a) Share Disconnected



(b) Unpaid Balance



(c) Days Overdue



(d) Monthly Payment

(e) Average Consumption

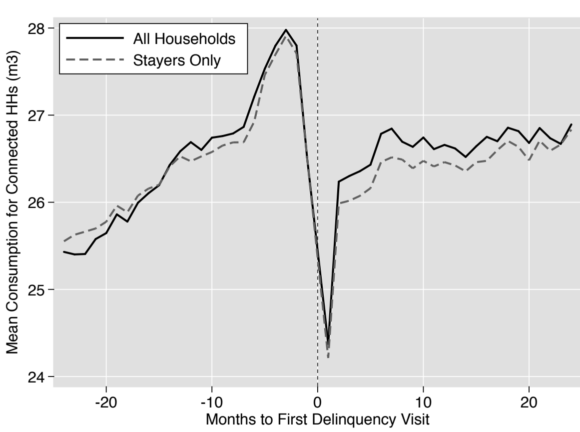


Figure 2. Mean Outcomes around First Delinquency Visit

Figures include all households with delinquency visits. Stayers include only households who are connected for the last 6 months of the sample. Mean monthly payments include zeros when no payment is made.

quency visits as well as stayer households who experience visits and also remain connected for the last 6 months of the sample. In the months just preceding a visit, monthly payments (Figure 2d) decrease suddenly, leading to corresponding increases in unpaid balances (Figure 2b) and days overdue (Figure 2c). Average consumption (Figure 2e) increases slightly as well. Prior to disconnection, stayers follow similar patterns but with lower levels of delinquency than the population average.

Immediately following the first delinquency visit, monthly payments spike as many households pay their full outstanding balances to prevent any disconnection. Despite these payments, the average share of households disconnected (Figure 2a) also spikes to around 24% before decreasing, as some households pay for reconnection, and stabilizing at 17%, which is likely composed of households who have permanently disconnected. Stayer households pay more and disconnect less than the population average following a visit. Disconnection rates for stayers spike to 15% before declining to around 4% two years later.[7] The decline among stayers accounts for much of the average decline in disconnection rates across the sample. Although many stayers quickly reconnect within 6 months, reconnections continue accumulating up to one year after a visit.

This descriptive evidence indicates that many households choose to disconnect for long periods before finally paying for reconnection. This behavior is consistent with households facing credit-constraints, which prevent them from taking a low-cost loan to fund immediate reconnection. Instead, households substitute to lower-quality alternative sources of water until they can save enough income for reconnection. Credit constraints would additionally predict that the most delinquent households at the time of the visit may be the most likely to disconnect following a visit. The data support this hypothesis, finding that the share disconnected two months after a visit is 32% for stayers that are over 90 days delinquent at the time of the visit. The corresponding share for stayers under 90 days delinquent shrinks to 4%.

Another hypothesis may be that households choose to stop paying when they leave their homes for vacation or overseas work. This mechanism would likely predict a large decrease in water consumption in the months preceding delinquency visits. Instead, consumption rises consistently between 24 and 2 months before a visit. Consumption then drops one month before, during, and after a visit, before quickly returning to an average level. This dip in consumption likely corresponds to connections that are disconnected for less than a month before being reconnected and having their consumption recorded for that month. Overall, this variation is small given a mean consumption for stayers of 26.2 m3 with a standard deviation of 12.3. Moreover, delinquency visits are relatively rare, which may make their exact timing difficult for households to predict.

[7] Although stayers are connected for the last 6 months of the sample by definition, disconnection rates do not decline to zero since some stayers experience multiple disconnection spells.

5. Model

Intro:

5.1. Setting up the Household's Problem

Time horizon etc. Ignore disconnecting households..

Households maximize their expected utility given by the following equation

$$E_t\Big[\sum_{\tau=t}^{t-\tau}(1+\delta)^{t-\tau}u(w_\tau, x_\tau)\Big] \tag{1}$$

where utility in each period t is expressed as an increasing and concave function of water consumption, w_τ, and consumption of all other goods, which are collapsed into a single term, x_τ. Households have a rate of time preference $\delta > 0$. In each period, households face a budget constraint as follows

$$x_t + p(w_t)w_t = y_t - D_{t+1}f + S_t - S_{t+1} \tag{2}$$

where $p(w_t)$ captures the price per unit of water and may change with water use according to the tariff structure. The price of other goods, x_t, is normalized to one. y_t represents household income each period which takes a value of $(1+\theta)\bar{y}$ with probability $\pi \in (0,1)$ and a value of $(1-\theta)\bar{y}$ with probability $(1-\pi)$ where $\theta \in (0,1)$. At the beginning of each period, households can choose whether to temporarily disconnect from water service $D_{t+1} = 1$ or remain connected $D_{t+1} = 0$. If households disconnect, they pay a fixed cost f. Since disconnected households are likely to share with neighbors or purchase from vendors who resell piped water, these households are assumed to face the same price schedule as connected households. Disconnecting also affects each household's ability to use an unpaid water bill as an asset. S_t captures assets chosen in the previous period to be consumed in period t while S_{t+1} captures assets set aside in period t for consumption in $t+1$. Total assets in each period can be expressed in terms of two types, A_t and B_t given by the following expression

$$S_t = A_t + B_t \tag{3}$$

$$S_{t+1} = \frac{A_{t+1}}{1+r_t^a} + I_t\frac{B_{t+1}}{1+r_t^b} \tag{4}$$

A_t captures standard assets for borrowing and saving. The real interest rate r_a is assumed to take a value of r_l when households are saving ($A_{t+1} \leq 0$) and a value of r_h when households are borrowing ($A_{t+1} > 0$). This wedge in interest rates is intended to capture an institutional context with underdeveloped financial markets where households face high borrowing costs from moneylenders as well as high transaction costs in loaning out their own savings. Households are unconstrained in their amount of borrowing or saving with this asset.

B_t captures borrowing through unpaid water bills. Households face a real interest rate r_b for borrowing from water bills. To prevent arbitrage cases where households borrow infinitely from water bills to invest in standard assets, r_b is assumed to equal r_h when households are saving through standard assets ($A_t > 0$), and is equal to r_w otherwise. Since the water company is not allowed to charge interest on outstanding balances, r_w is equal to zero in this setting.

I_t determines when households are able to borrow from their unpaid water bills and takes the following form

$$I_t = D_{t+1} + (1 - c_t)(1 - D_t)(1 - D_{t+1}) \tag{5}$$

where c_t indicates whether a household receives a delinquency visit, which occurs with probability $\lambda \in (0, 1)$ in each period and D_{t+1} indicates the household's disconnection choice given their disconnection status D_t. If households receive a delinquency visit ($c_t = 1$) and they choose to remain connected ($D_{t+1} = 0$), then they must pay their full outstanding balance to remain connected, which means that households cannot continue borrowing against their unpaid water bill this period. Similarly, if disconnected households ($D_t = 1$) want to reconnect ($D_{t+1} = 0$), then they also need to pay their outstanding balance. Choosing to disconnect ($D_{t+1} = 1$) allows households to avoid paying their unpaid balances until they choose to reconnect.

Given that households are able to borrow, the amount that they can borrow through unpaid bills is constrained as follows

$$B_t - p(w_t)w_t(1 - D_{t+1})(1 + r_b) \leq B_{t+1} \leq 0 \tag{6}$$

By leaving bills unpaid, households are able to borrow up to their existing outstanding balance, B_t, plus their total bill from water consumption, $p(w_t)w_t$, given that they stay connected to service, $D_{t+1} = 0$. If households choose to disconnect, then they can maintain their existing outstanding balance, but cannot add to this balance through unpaid water use. To capture the fact that water bills are almost never overpaid, households are assumed to be unable to save with this asset.

This framework creates four possible states depending on whether income, y_t, is high or low and whether households receive a delinquency visit given by the indicator variable, c_t. Assuming that the probabilities of reaching each state are uncorrelated with each other yields the following transition matrix between states:

$$T_{t,t+1} = \begin{array}{r} \\ (1+\theta)\bar{y}\text{, no visit} \\ (1-\theta)\bar{y}\text{, no visit} \\ (1+\theta)\bar{y}\text{, visit} \\ (1-\theta)\bar{y}\text{, visit} \end{array} \begin{array}{c} \begin{array}{cccc} (1+\theta)\bar{y}\text{, no visit} & (1-\theta)\bar{y}\text{, no visit} & (1+\theta)\bar{y}\text{, visit} & (1-\theta)\bar{y}\text{, visit} \end{array} \\ \begin{pmatrix} \pi(1-\lambda) & (1-\pi)(1-\lambda) & \pi\lambda & (1-\pi)\lambda \\ \pi(1-\lambda) & (1-\pi)(1-\lambda) & \pi\lambda & (1-\pi)\lambda \\ \pi(1-\lambda) & (1-\pi)(1-\lambda) & \pi\lambda & (1-\pi)\lambda \\ \pi(1-\lambda) & (1-\pi)(1-\lambda) & \pi\lambda & (1-\pi)\lambda \end{pmatrix} \end{array}$$

5.2. Solving the Model

The problem can be reformulated using a recursive value function approach where the household solves for a function, $V(X_t, z_t)$, that maximizes both current utility and the expected continuation value given current asset-levels and disconnection status captured by X_t as well as current states given by z_t below

$$
\begin{aligned}
V(X_t, z_t) \; = max_{x_t, w_t} \;\; & u(x_t, w_t) \; + \; (1+\delta)^{-1} E\Big[\, V(X_{t+1}|z_t) \,\Big| z_{t+1}, T_{t,t+1}\Big] \\
s.t. & \\
& x_t \; + \; p(w_t)w_t \; = \; y_t \; - D_{t+1} f \; + \; S_t \; - \; S_{t+1} \\
& -p(w_t)w_t(1 - D_{t+1}) \leq \frac{B_{t+1} - B_t}{(1 + r_b)} \leq 0 \\
& X_t \; = [A_t, B_t, D_t] \\
& z_t \; = [y_t, c_t]
\end{aligned}
\tag{7}
$$

This problem can be divided into two steps: (1) maximizing utility within a given period by choosing w_t and x_t holding asset levels fixed, and (2) choosing asset values to maximize utility over time.

Each period, households face a standard utility maximization problem except in cases where they need to overconsume water to raise enough revenue through unpaid water bills to meet their borrowing goals. Formally, this situation occurs when equation (6) is binding. To solve this problem, let $L = \frac{B_{t+1} - B_t}{1 + r_t^b}$ indicate the amount of revenue needed to be raised through water consumption to fund borrowing levels. Likewise, let $Y = y_t - D_{t+1} f + A_t + B_t - \frac{A_{t+1}}{1 + r_t^a} - I_t \frac{B_t}{1 + r_t^b}$ equal all other income each period. Also, let utility take a Cobb-Douglas shape in water and all other goods with preference parameter, $\alpha \in (0, 1)$. Cobb-Douglas preferences assume that households spend a constant share of their income on water and that the price-elasticity of demand for water is equal to one, which is close to recent estimates in the literature.[8] The Cobb-Douglas utility function is also assumed to take a log-log form, which determines how households smooth income over time.[9]

The price of water is parameterized as a linear function of water use, $p(w) = p_1 + p_2 w$, to approximate the increasing block tariff present in Manila. Suppressing most time subscripts for ease of exposition, the household maximization problem takes the following form within each period

$$
\begin{aligned}
& max_{w_t, x_t} \;\; \alpha \, log(w) \; + \; (1 - \alpha) \, log(x) \\
s.t. & \\
& (p_1 + p_2 w) \, w + x = Y - L \\
& (p_1 + p_2 w) \, w (1 - D_{t+1}) \leq L
\end{aligned}
\tag{8}
$$

[8] Violette [2019] finds an average price elasticity of 0.84 in this setting while Szabó [2015] finds an average price elasticity of 0.98 in South Africa.

[9] CITE SOME LITERATURE HERE?!

Optimal consumption takes a piecewise form depending on whether households have to use more water to satisfy demand for borrowing each period

$$w^* = \begin{cases} \frac{p_1 - \sqrt{p_1{}^2 - 8\,L\,\alpha\,p_2 + 8\,Y\,\alpha\,p_2 + 4\,L\,\alpha^2\,p_2 - 4\,Y\,\alpha^2\,p_2}}{2\,p_2\,(\alpha-2)} & \text{if } L \geq \widehat{L} \\ -\frac{p_1 - \sqrt{p_1{}^2 - 4\,L\,p_2}}{2\,p_2} & \text{if } L < \widehat{L} \end{cases}$$
$$\widehat{L} = \frac{Y}{2\,(\alpha - 1)} + \frac{\frac{Y\,p_2}{2} + \frac{p_1{}^2}{8} - \frac{p_1\,\sqrt{p_1{}^2 - \alpha\,p_1{}^2 + 8\,Y\,\alpha\,p_2}}{8\,\sqrt{1-\alpha}}}{p_2} \tag{9}$$

where $\widehat{L}$ captures the point at which revenue demanded for borrowing is exactly generated by the household's optimal consumption. When borrowing demand outpaces revenue from optimal consumption (ie. $L < \widehat{L}$), then households must deviate from their optimal consumption choice and instead consume enough water to exactly satisfy borrowing demand. This overconsumption captures a possibly important inefficiency associated with using unpaid water bills as a source of credit. Combining optimal consumption in equation (9) with the budget constraint in equation (2) and the utility function in equation (8) provides an indirect utility function as a function of prices, income, and assets. The full indirect utility function is given by equation (10) in Appendix 8.3.

Given indirect utility in each period and a discount rate that is greater than the interest rates, $\delta > max\{r_a, r_b\}$, households solve for a value function in (7) that maximizes utility by mapping any combination of asset levels into period t into future asset levels in period $t + 1$.

6. Model Primitives

The estimation allows households to choose over 25 values of the standard asset, A_t, evenly spaced across a normal distribution with a standard deviation of 10,000, a minimum of -17,688, and a maximum of 17,688. Households can also choose how much to borrow from unpaid water bills, B_t, over 26 values evenly spaced across a normal distribution truncated above at 0 with a standard deviation of 3,800 and a minimum of -7,835. The additional choice of whether to stay connected each period given by D_t brings the total possible number of asset combinations to 1,300.

To generate simulated moments, the estimator creates a random 5,000 month chain of states and calculates the household's predicted asset and consumption choices (assuming asset levels of zero to start).

Table 3. Calibrated and Assumed Parameters

Savings Rate	r_l	0.30%	Philippines data from World Bank Databank (2010-2015)
Water Rate	r_w	0%	Regulators prevent charging interest
Discount Rate	δ	2%	Mean of structural estimates from literature†
Tariff	$(p_1 + p_2 w)$	$(20.2 + 0.2w)$	Estimated price by water usage (See Appendix 8.4 for details)
Mean Inc. (PhP)	$\bar{y}$	31,910	Family Income Expenditure Survey (2015) for Manila
High Inc. Risk	π	50%	Assumed to ensure symmetric income shocks
Visit Risk	λ	4.04%	% of months with a visit among stayers with >31 days overdue

All measures are monthly. Annual rates are converted to monthly rates as follows: Monthly Rate = $(1 + \text{Annual Rate})^{1/12} - 1$
† See Andreoni and Sprenger [2012], Laibson et al. [2007], and Gourinchas and Parker [2002] for structural δ estimates.

Table 4. Parameters to be Estimated

Parameters		Main Identifying Moments
Water Preference (Cobb-Douglas)	α	Mean Usage
Income Shock Magnitude	θ	Mean Outstanding Balance
Fixed Cost of being Disconnected	f	% Disconnected 1-4 months post visit
Borrowing Rate from Standard Assets	r_h	% Disconnected 1-4 months post visit given 90+ days overdue when visited

7. Results

Table 5. Estimates

Parameters		Estimates
Water Preference (Cobb-Douglas)	α	0.025
		(0.00013)
Income Shock Magnitude	θ	0.207
		(0.0060)
Fixed Cost of being Disconnected (PhP)	f	198.9
		(4.1719)
Borrowing Rate from Standard Assets	r_h	0.038
		(0.0011)
Households		8,260
Household-Months		509,959

Standard errors in parentheses are bootstrapped with 4 repetitions at the household-level.

Karlan and Zinman [2009] find money lenders regularly charge at least 20% per month for credit. Giné and Karlan [2014] offer small monthly loans of 1,000 PhP at 2.5% monthly interest.

Table 6. Model Fit

Moments Used in Estimation	Data	Predicted
Mean Usage (m3)	26.20	26.20
Mean Water Debt (PhP)	2415.8	2341.1
% Disconnected Post-Visit		
1 month	0.13	0.12
2 months	0.14	0.10
3 months	0.12	0.06
4 months	0.10	0.05
% Disconnected Post-Visit given 90+ days overdue when visited		
1 month	0.30	0.28
2 months	0.32	0.23
3 months	0.26	0.13
4 months	0.23	0.11
Out of Sample		
SD of Usage	12.3	2.4
SD Water Debt (PhP)	3589	2635
Corr. Usage and Water Debt	0.31	-0.02

Figure 3. 100 Months of Simulated Data

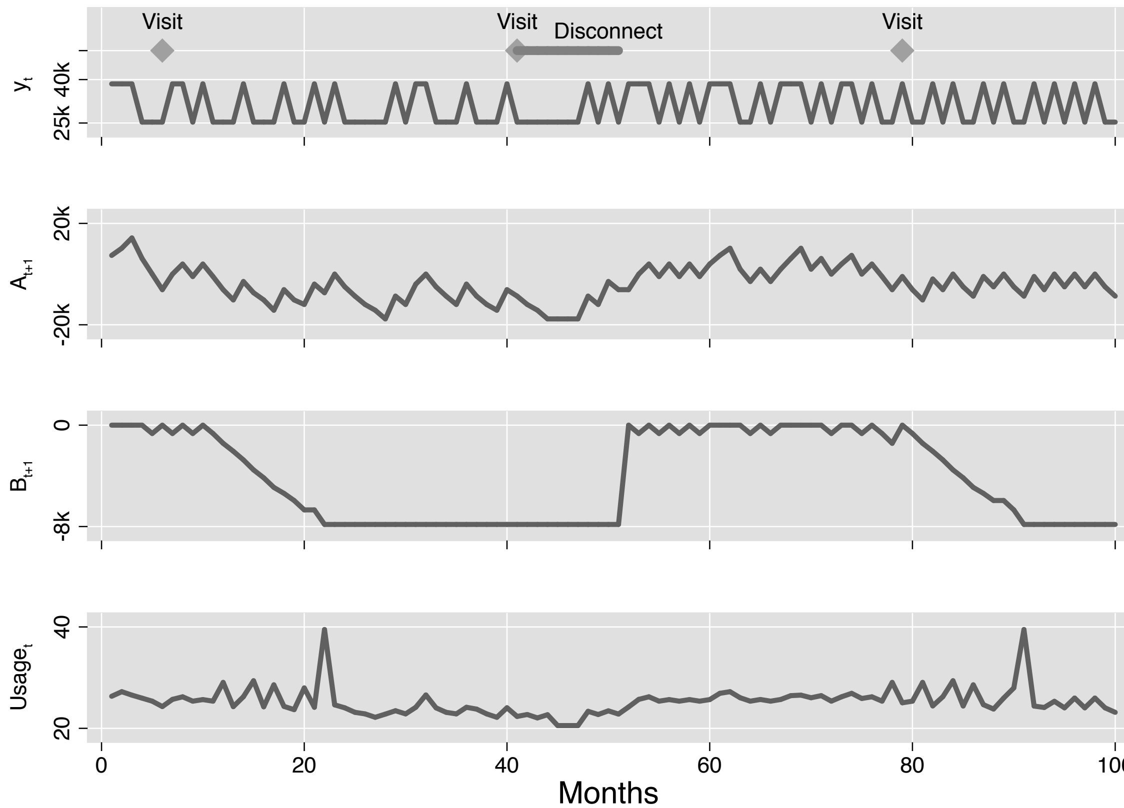


Table 7. Counterfactuals

	Current	No Water Credit	No Water Credit and Revenue Neutral
Water Credit Interest Rate	0.0	1.0	1.0
Mean Usage (m3)	26.2	24.9	26.7
Compensating Variation		-52.4	3.2
Delinquency Savings	20.8	20.8	0.0
Price Intercept	20.2	20.2	17.3

8. Appendix

8.1. Predicting Delinquency Visits

Table 8. Linear Probability of Receiving a Delinquency Visit

	(1)	(2)	(3)
Usage t-1	-0.0000150[a]	-0.0000186[a]	-0.0000225[a]
	(0.0000052)	(0.0000052)	(0.0000079)
Days Delinquent t-1	0.0000524[a]	0.0000581[a]	0.0000499[a]
	(0.0000016)	(0.0000016)	(0.0000020)
Unpaid Balance t-1	0.0000009[a]	0.0000009[a]	0.0000011[a]
	(0.0000001)	(0.0000001)	(0.0000001)
Single House	-0.0001480	-0.0001468	
	(0.0002032)	(0.0002050)	
Apartment	-0.0004173[b]	-0.0005555[a]	
	(0.0001861)	(0.0001869)	
Age of HoH	-0.0000398[a]	-0.0000373[a]	
	(0.0000040)	(0.0000040)	
HoH Low Skill Empl.	0.0005415[a]	0.0005333[a]	
	(0.0001827)	(0.0001830)	
HH Size	0.0003462[a]	0.0003482[a]	
	(0.0000363)	(0.0000364)	
Employed HH Members	-0.0002883[a]	-0.0002957[a]	
	(0.0000573)	(0.0000574)	
Location		✓	
Year $\times$ Month FE		✓	✓
Household FE			✓
N	1,951,543	1,948,783	1,951,543
Mean Visits Per Month	0.0072	0.0072	0.0072

Std. errors clustered at the HH-level. [c] p<0.10,[b] p<0.05,[a] p<0.01

8.2. Sample Construction

Table 9. Sample Construction

	Observations	Observations Removed
Initial sample	3,343,644	
Keep residential connections (excluding commercial)		414,615
Keep connections with payment records		68,509
Keep months with consumption under 200 m3		8,669
Keep bills > -5,000 PhP and < 80,000 PhP		116
Keep unpaid bills > -5,000 PhP and < 80,000 PhP		5,893
Keep payments > -80,000 PhP and < 80,000 PhP		1
Keep connections with over 30 months of records		1,360
Keep connections serving a single household		721,146
Drop connections that are disconnected for final yr.		92,459
Final sample	2,030,876	

8.3. Indirect Utility Function

$$v^* = \begin{cases} \alpha \ \ln(\frac{p_1 - \sqrt{{p_1}^2 - 8\,L\,\alpha\,p_2 + 8\,Y\,\alpha\,p_2 + 4\,L\,\alpha^2\,p_2 - 4\,Y\,\alpha^2\,p_2}}{2\,p_2\,(\alpha-2)}) - \\ \ln(\frac{(\alpha-1)\,(8\,L - 8\,Y - 4\,L\,\alpha + 4\,Y\,\alpha)}{2\,(\alpha-2)^2} + \\ \frac{(p_1\,\sqrt{{p_1}^2 - 8\,L\,\alpha\,p_2 + 8\,Y\,\alpha\,p_2 + 4\,L\,\alpha^2\,p_2 - 4\,Y\,\alpha^2\,p_2} - {p_1}^2)\,(\alpha-1)}{2\,p_2\,(\alpha-2)^2})\,(\alpha-1) & \text{if } L \geq \widehat{L} \\ \alpha \ \ln\left(-\frac{p_1 - \sqrt{{p_1}^2 - 4\,L\,p_2}}{2\,p_2}\right) - \ln(Y)\ (\alpha-1) & \text{if } L < \widehat{L} \end{cases} \tag{10}$$

$$\widehat{L} = \frac{Y}{2\ (\alpha-1)} + \frac{\frac{Y\,p_2}{2} + \frac{{p_1}^2}{8} - \frac{p_1\,\sqrt{{p_1}^2 - \alpha\,{p_1}^2 + 8\,Y\,\alpha\,p_2}}{8\,\sqrt{1-\alpha}}}{p_2}$$

8.4. Tariff Structure and Approximation

Table 10. Example Residential Tariff As Presented to Consumers

Usage (m3)	Price (PhP)
Under 10	104.12 /conn.
Over 10	180.79 /conn.
Next 10	19.26 /cu.m.
Next 20	25.50 /cu.m.
Next 20	33.56 /cu.m.
Next 20	40.16 /cu.m.
Next 20	45.23 /cu.m.
Next 50	50.21 /cu.m.
Next 50	56.37 /cu.m.
Over 200	58.74 /cu.m.

Mean tariff 2010-2015 with value added tax.
"conn." refers to connection.
"cu.m." refers to m3/month. 50 PhP~1 USD

Table 10 provides the monthly tariff structure as it is presented to consumers. Consumers face a fixed price as well as marginal prices for any usage above 10 m3. The marginal price is highly non-linear, accelerating quickly at low usage levels before slowly increasing at high usage levels. To achieve a tractable approximation of this price schedule, Table 11 fits a simple regression model predicting average price as a function of an intercept, p_1, and monthly usage levels, p_2. This model predicts that a increase in monthly usage of 10 m3 results in an increase in average price of 2.2 PhP/m3.

Table 11. Average Price and Monthly Usage

	Avg. Price: $\frac{\text{Bill (PhP)}}{\text{Usage (m3)}}$
Usage (m3)	0.22^{a}
	(0.01)
Intercept	20.23^{a}
	(0.17)
Household-Months	476,862

^{c} $p<0.10$, ^{b} $p<0.05$, ^{a} $p<0.01$

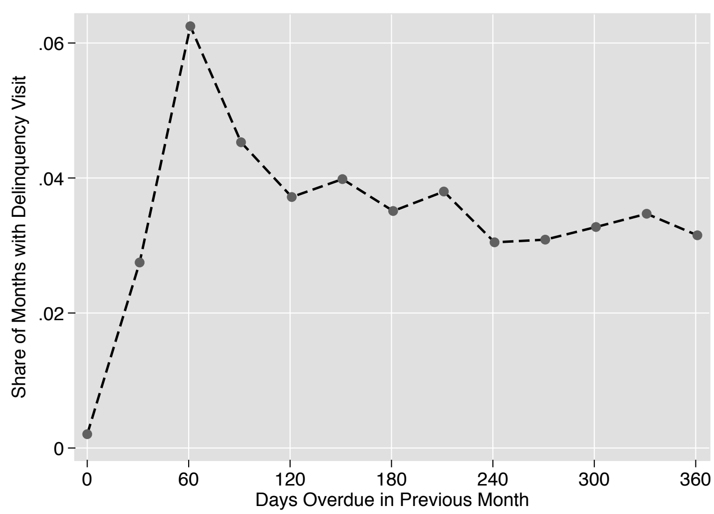
8.5. Stayer Descriptives

Table 12. Descriptives for Stayers

	Mean	SD	Min	25th	75th	Max
Usage (m3)	26.2	17.5	0.0	15.0	33.0	200.0
Bill	761	1,124	-4,640	287	920	78,409
Unpaid Balance	2,416	5,070	-4,995	261	2,346	79,904
Share of Months with Payment	0.60	0.49	0.00	0.00	1.00	1.00
Payment Size	1,214	1,498	0	426	1,482	61,298
Days Delinquent	84.9	155.4	0.0	0.0	91.0	720.0
Delinquency Visits per HH	1.32	0.61	1.00	1.00	2.00	6.00
Months Disconnected	0.03	0.17	0.00	0.00	0.00	1.00

Total Households: 8,260 Obs. per Household: 61.8 Total Obs.: 509,959

Figure 4. Stayers Share of Households that Receive a Delinquency Visit depending on Days Delinquent in the Previous Month



Only stayer households.

8.6. Discussion of the Discount Rate

Andreoni and Sprenger [2012] estimate rates between 25% and 35% in an experimental setting and confirm exponential discounting. Laibson et al. [2007] use a similar consumption-savings structural approach and recover a discount rate of around 15%. Gourinchas and Parker [2002] use a similar structural approach finding a lower discount rate of around 5%.

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